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THE BIOLOGY AND CONTROL OF THE BLACK HILLS BEETLE

(DENDROCTONUS PONDEROSAE HOPK.)

Summary of Studies

in Colorado and Wyoming

1935-1938

By

Donald De Leon

Forest Insect Laboratory
Fort Collins, Colorado

May 13, 1939

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Graduate

No. JMW

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Forest Insect Laboratory,
210 Forestry Bldg., C.S.C.,
Fort Collins, Colorado.
May 13, 1939.

Dr. F. C. Craighead,

Washington, D. C.

Dear Doctor Craighead:

Enclosed are two copies of this year's report on the Black Hills beetle.

The report brings out many interesting points which will be checked by further work this coming field season. Some of the points which seem to be of importance are those such as the indication that the beetle shows a preference for small limber pine over small lodgepole pine but that no preference is shown for either of these species when they are over 18" dbh.

The beetle appears to select the slower growing trees for all three species and also the larger ones. At first sight it would appear that these were the older trees whose growth rates had begun to decline normally but I do not believe this to be the case for practically all the trees taken were in the same age class.

When checking the ratio of new adults emerging against the number of emergence holes per square foot it was found that in quite a few cases there were more emergence holes than emerging beetles. The emergence holes were all checked by removing the bark so that parent adult emergence holes were not counted in. I have long felt that the brood per square foot was greater than the tree cage data showed. Whether the beetles escaped or whether they have some unsuspected habits, I can not say, but we are planning to change the cages this year to eliminate any possibility of beetles escaping and thus possibly find out what did happen to the brood under the cages.

The difference in the number of attacks per square foot is surprising. For both lodgepole and limber pine the attacks per square foot are slightly more than double the number of attacks in ponderosa pine. In ponderosa pine the attacks in 1937 and 1938 averaged about 7 per square foot and during the past four years the number for each tree species has increased.

Quite a few other points have been brought out, a general idea of which can be obtained by looking over the summary.

Copies of this report are being sent to the western stations.

Very sincerely yours,

J. A. Beal, Entomologist,
Forest Insect Investigations.

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The Biology and Control of the Black Hills beetle (Dendroctonus ponderosae Hopk.)

(Summary of studies in Colorado and Wyoming 1935-1938)

INTRODUCTION

The present widespread outbreak of the Black Hills beetle in this region first became serious in 1933 and is still in epidemic form in many areas. It has required the expenditure of many thousands of dollars for control work to prevent serious losses to the pine stands. Although the general biology of this beetle was well known it was felt that a more detailed knowledge of its habits would assist not only in making appreciable savings in the cost of treating but also in doing a more effective job of treating.

This, the fourth report from this laboratory on the study of the Black Hills beetle, brings together all the data secured to date. Two previous reports (1, 2) presented the work done in 1935 and 1936 in the lodgepole and limber pine stands on Elk Mountain, Wyoming, and a third report (3) covered the work done in 1937 in the same region and that done in the ponderosa pine stands near Evergreen, Colo. As in the previous years, the 1938 studies for lodgepole and limber pine were carried out on Elk Mountain, but those in ponderosa pine were transferred to near Estes Park, Colorado. A list (4) of the insects found associated with the Black Hills beetle has also been made.

ACKNOWLEDGMENTS

This report is based on the work of more than a dozen different workers. First field work at Elk Mountain was done in 1935 by J. M. Whiteside, Carl Herzman, and J. A. Beal. The following years' work was done there as follows: in 1936 by Whiteside, Beal, L. G. Baumhofer, Galen Hinkle, and N. D. Wygant; in 1937 by Baumhofer, Wygant, C. L. Massey, and Ed Beals; in 1938 by Massey, R. J. Keller, and the writer. In the ponderosa pine stands field work was done in 1937 by Baumhofer, Beals, Massey, and Fred Lewis; in 1938 by Massey and the writer. Much of the office work in compiling the data collected in 1938 was done by Massey, and all the statistical analyses by W. L. Howe. J. A. Beal read practically all of the cores and compiled the data on which the growth curves were made. Mrs. G. L. Waterman read some of the cores from Estes Park.

LOCATION OF STUDIES

Miscellaneous observations have been made in many parts of Utah, Wyoming, and Colorado, but the studies were confined chiefly to Elk Mountain, near Saratoga, Wyoming, Mah Keeney Park, near Evergreen, Colorado, and the North St. Vrain Canyon near Estes Park, Colorado.

Elk Mountain is a rugged prominence rising in a short distance to a height of 11,162 feet from a basal elevation of about 7000 feet. It is covered with patchy stands of lodgepole pine, limber pine, Engelmann spruce, Douglas fir, and alpine fir (fig. 6). The Black Hills beetle infestation which developed in this area one or two years

Earlier than that in ponderosa pine stands is a very severe one. It has been estimated that over 200,000 trees were killed in 1936 on an area of about 10,240 acres. The infestation is chiefly between the 8000 and 10,000 foot contours and the majority of the trees killed have been limber pine.

In 1936 brief studies were made of a lodgepole pine infestation in the Mullison Creek area on the Medicine Bow National Forest, Wyoming, but no further work was done there because control work eliminated the infestation.

The ponderosa pine stands, starting at an elevation of about 5600 feet, are at an average lower elevation than the lodgepole and limber pine stands and generally in more rolling country. Infested trees are found chiefly above 7,500 feet elevation. Wah Keeney Park and the North St. Vrain Canyon study-areas are both at about this elevation.

DISTRIBUTION

According to Hopkins (6) the beetle has been collected from southern Arizona (Chiricahua National Forest) and New Mexico (Gila National Forest) northward through Utah, Colorado, the eastern half of Wyoming, and the Black Hills of South Dakota. On his map of its distribution, p. 114, he indicates that it may also be found from upper Baja California, southern California, the northern Sierra Madre mountains of Mexico and eastward through New Mexico and the Big Bend country of Texas.

Blackman (7) in a study in which he critically examined 2,868 specimens of this insect and its nearest relative, the mountain pine beetle, D. monticolae Hopk., indicates that in northern Utah (Ashley National Forest) and southeastern Wyoming (Elk Mountain) there is a mixed infestation of these two beetles. In the former area only 4 percent of the 208 specimens examined were typical D. ponderosae, the remainder being either typical D. monticolae or intermediates; in the latter area 70 percent of the 509 specimens examined were typical D. ponderosae, the remainder approaching the D. monticolae characters. Material from Sula, Montana, and Coeur d'Alene, Idaho, was respectively 99 percent and 98 percent typical D. monticolae. The atypical specimens apparently fitted or approached the characters of D. ponderosae. From this it is seen that although these two "species" can be separated when typical specimens are available, specimens which intergrade are found so widely that in all probability we are dealing with a single species which varies according to host, condition of food supply, and region.

Until it has been shown that the progeny of typical D. ponderosae when reared under various conditions develop into typical D. monticolae adults, that the reverse is also true, and that we actually are dealing with but a single variable species, it would seem best to consider the two types distinct species. For convenience, however, specimens collected from within the range of the Black Hills beetle as mapped by Hopkins will be considered that species in this report.

HOSTS

The Black Hills beetle has been recorded by Hopkins (l.c.) from the following hosts:

Pinus ponderosa
" *flexilis*
" *contorta*
" *strobiformis*
Picea engelmannii

Blackman (8) lists the following additional hosts: *Pinus aristata*, *P. edulis*, and *Picea mungens*. The writer has also collected it from *Pseudotsuga taxifolia*, and C. L. Massey has collected it from *Abies lasiocarpa* but in neither of these cases were the attacks successful.

The principal host trees are ponderosa pine, limber pine, and lodgepole pine. Greatest brood development has been found to occur in limber pine, where a maximum of 509 beetles were reared from two square feet of bark. Average emergence from 28 square feet of bark was 174 beetles. This is by far the greatest emergence per square foot that has been found for these three host trees.

DESCRIPTION OF STAGES

Adult. The average size of adults from the three principal host trees varies considerably as is shown by table I.

Table I.--Mean sizes in millimeters of 100 specimens of each sex reared from the three principal host trees.

	Lodgepole pine*		Limber pine		Ponderosa pine**			
	Male	Female	Male	Female	Male		Female	
Year of emergence	1936	1936	1936	1939	1937	1938	1937	1938
Mean	4.7(1)	5.0(2)	5.2	5.7	5.7	5.6	6.3	6.0
Minimum	3.9	3.7	3.9	4.8	4.6	4.6	4.9	4.7
Maximum	5.5	6.0	6.0	6.7	6.8	6.8	7.0	7.4

* beetles from trees attacked in 1936.
**beetles collected in 1937 from Evergreen, Colorado; in 1938 from Estes Park, Colorado.
(1) based on 43 specimens
(2) based on 46 specimens

Whether the beetles from lodgepole pine are smaller because of being second-year beetles or because of host difference is not known. It would appear that some condition of the host must account for the difference in size of the beetles from these three trees.

Egg.--The egg is oval, pearly white, the chorion thin and very slightly roughened but with no characteristic markings. The measurements of nine eggs collected in 1938 from ponderosa pine follow:

Size in mm

Length	Width
1.26	0.72
1.11	0.60
1.16	0.68
1.29	0.72
1.22	0.72
1.20	0.72
1.17	0.68
1.26	0.72
Mean 1.21	0.69

Larva and pupa.--No studies were made on the larva or pupa during the present investigation.

LIFE HISTORY AND HABITS

METHODS OF STUDY

Considerable time during the past four years was expended on the erection of rearing cages (Figure 1) and collections from these cages. Each cage covered an area one foot wide and two feet long. A preservative such as formaldehyde, acetic acid, and alcohol was kept in the collection jars to prevent deterioration of the specimens trapped. These cages were fastened to infested trees the spring following the attack and collections made from them two or three times a week the season of emergence and every two weeks or so the following seasons. In this way a record of the period of, and the peaks of, emergence of the beetles was accurately secured. In addition a record was secured of the emergence per square-foot of the beetle and of the insects associated with it at the time the cages were erected. The erection of the cages did prevent, however, securing any records of subsequent parasitism, and inasmuch as certain parasites do most of their parasitizing after the time the cages are usually erected the effect of these insects in reducing the amount of beetle brood could not be determined. Cages have been established as follows:

Table II

Elevation in feet	Number of Trees Caged									
	Lodgepole Pine			Limber Pine				Ponderosa Pine	
	1935	1936	1937	1935	1936	1937	1938	1937	1938
8,000	3	3	0	2	3	5	3	20	13
9,000	3	2	3	2	1	5	0		
10,000	2	2	3	3	4	3	0		
	8	7	10	7	9	13	3	20	12
Total No. trees caged			25				34		32

Cages were placed, where possible, on the north and south sides of each tree. In some cases a cage was placed on the east or west side and in a few instances only one cage was placed on a tree. The first cages used were placed within a foot or so of the ground, but during the last three years they were placed as high as one could reach from the ground except at Wah Keeney Park where a ladder was used when erecting them. In this case the collecting-jar was about 5 feet from the ground.

After the cages had been up at least two seasons they were removed, the emergence holes made by the new adults and the parent adults counted, then the bark removed and the number of attacks counted and inches of gallery measured within the area caged. In addition to the counts and measurements made within the areas caged additional records were secured of the brood, attacks per square foot, and lengths of galleries in many other trees.

TREE SELECTION BY THE BLACK HILLS BEETLE

Selection by Species

During 1938 six cages were constructed and covered with #16 galvanized wire. Four of the cages were 5' by 5' by 5' and two 5' by 5' by 2½' (Figure 2). Two logs were placed in the smaller cages and four in the larger ones. The set-up is shown in table III.

Table III.--Attacks per square foot by the Black Hills beetle on green caged logs.

Cage No.	Species of green log	Log No.*	Attacks per sq. ft.	No. beetles placed in cage and source tree	No. beetles added per sq.ft.
1	Lodgepole	1	.15	140--Lodgepole	3.9
		4	.80		
	Limber	2	3.57		
		3	.11		
2	Lodgepole	2	2.92	150--Limber	4.0
		3	.80		
	Limber	1	2.15		
		4	.75		
3	Lodgepole	1	.01	150--Limber	3.8
		2	.73		
		3	1.10		
		4	.30		
4	Limber	1	1.97	75--Limber	4.1
		2	.00		
5	Lodgepole	1	2.55	75--Lodgepole	4.4
		2	.80		
6	Limber cut Aug.15	1	5.32	150--Lodgepole	5.2
		2	1.29		
	Limber cut Aug. 9	3	.71		
		4	.40		

*Each log was about 3' long and 12" in diameter.

The data in the table above do not indicate that preference is shown by beetles from lodgepole pine or limber pine for either of these two trees. Cage studies based on log sections, however, are highly inaccurate when it comes to showing preference for a particular species, and it is believed that the data of the two sample plots in table IV are much more significant.

Table IV.--Timber losses since 1933 on Plots I and II, Elk Mountain, Wyoming.

Diameter class in inches	Lodgepole Pine: Stand in 1933	Lodgepole Pine: Loss 1934-1938	Lodgepole Pine: Percent loss	Limber Pine: Stand in 1933	Limber Pine: Loss 1934-1938	Limber Pine: Percent loss
Plot I (12 acres)						
6-12	613	84	13.7	920	772	83.9
13-18	71	28	39.4	100	95	95.0
19-24	3	3	100.0	3	2	66.6
25-30	1	1	100.00	1	1	100.0
Plot II (23 acres)						
6-12	943	173	18.3	456	306	67.1
13-18	419	231	55.1	151	118	78.1
19-24	39	35	89.7	52	46	88.5
25-30	0	0	--	4	3	75.0

These data indicate quite definitely that with trees up to 18" dbh the beetle shows a decided preference for limber pine but for trees over 18" dbh there seems to be little preference. This is probably because of the thicker bark of the large lodgepole pines. Knowledge of how the beetles are able to make this distinction would be highly valuable.

Selection by Size

Data compiled from the Forest Service spotting records of the Roosevelt National Forest and from the two sample plots on Elk Mountain, Wyoming, indicate that in any given year stand composition has a determining effect on the size of the trees attacked but that in a given area these diameters change significantly with the condition of the infestation. This is shown in table V and table VI.

Table V.--Mean diameter in inches of infested trees*.

Trees attacked:	Tree species by locality										
	Limber pine				Lodgepole pine			Ponderosa pine			
	Elk Mountain		Boulder	Grace	Elk Mountain		Boulder	Magnolia	Big Elk	Elk Ridge	Fish
	Plot I	Plot II	Ridge	Creek	Plot I	Plot II	Ridge		Park	N.St.Vrain	Creek
1934	10.7				9.7						
1935	10.0	11.9	11.9		11.0	14.2					
1936	9.6	11.8			12.1	13.1	13.9		16.0		
1937	9.4	12.1			9.0	13.8		10.3	10.2	12.0	
1938	9.5	12.5	8.5	11.0	9.0	11.2	12.1	11.4		10.6	11.5

*based on a total of 8674 spotted trees.

Table VI.--Comparison of mean diameters of present stand (1939) with those of mean diameters of trees hit since 1933.

	Elk Mountain, Wyoming			
	Tree species*			
	Lodgepole pine		Limber pine	
	Plot I 12 acres	Plot II 23 acres	Plot I 12 acres	Plot II 23 acres
Present stand	9.5	10.3	9.3	10.6
Trees attacked:				
1934	9.7		10.7	
1935	11.0	14.2	10.0	11.9
1936	12.1	13.1	9.6	11.8
1937	9.0**	13.8	9.4	12.1
1938	9.0**	11.2	9.5	12.5

*trees 6" dbh or above

**only a total of seven trees were hit for these two years.

In all cases, with the exception of lodgepole pine for 1937 and 1938, the mean diameter of the trees attacked is larger than the mean diameter of the uninfested trees at the end of the 1938 season; this in spite of the fact that the general trend of the mean diameter of the infested trees was downward each year. The data in table IV also seem to bear this out.

Selection by Condition of Species

Trap trees and logs.--No work was done on this phase of beetle preference. Blackman (8) has shown that beetles are attracted to recently felled logs more strongly than to logs felled some time. In neither case, however, did heavy brood develop but he points out that this may not always be the case. The same author also mentions that hack girdled and belt girdled trees were not preferred to uninjured trees.

During the spring of 1937 a severe snowstorm in the Black Hills of South Dakota caused considerable top breakage to the ponderosa pine, the tops of which were broken off twenty to thirty feet from the ground. The standing boles in nearly all cases were filled in in August by the beetle but the broken tops wherever examined showed no evidence of Black Hills beetle attacks. Heavy emergence occurred from these snags the following year, large groups of green trees being attacked all over the snowbreak area*.

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*Memorandum on insect conditions on the Harney and Black Hills National Forests in South Dakota, by D. A. Hester. MS Report. December 1938. Fort Collins, Colo.

Examples like this bear out the statements of Blackman (2) that the brood of the Black Hills beetle reaches its best development where there is ample moisture in the phloem and that it does poorly where the phloem does not have a good supply of moisture.

Uninjured trees.--The effect of tree vigor and growth rate on selection of individual trees by beetles is a complex one and many factors which we are entirely ignorant of no doubt enter into the picture.

Although the lower limit of ponderosa pine in northern Colorado is at about the 5600-foot contour, beetle outbreaks in this region almost invariably occur above 7500 feet.* The trees in these lower marginal stands do not put on good growth and are commonly killed by Ips and flatheads. Yet even areas where these insects are doing considerable damage and which are practically adjacent to outbreak areas of the Black Hills beetle show no attacks of the latter insect.

According to studies made by Rudolf Stahelin of the Rocky Mountain Forest and Range Experiment Station there are on the average about 2 inches more precipitation at 7500 feet than at 5500 feet. Precipitation at 7500 feet is about 20 inches in the northeastern portion of the front range.

When one takes cores of those trees killed in outbreak areas, i.e., areas above 7500 feet, and compares their growth with green trees of the same area, one sees immediately that the average growth rate of the attacked trees is lower than that of the green trees. This

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*The only exception known occurred in the Turkey Creek drainage near Evergreen, Colorado, where a very heavy infestation was present at an elevation as low as 6,500 feet.

was also found to be true in the lodgepole and limber pine stands on Elk Mountain. Graph 1 shows the growth curves for ten years for green trees and attacked trees of the three principal host species. Table VIa shows the percent greater growth made by these green trees over the growth of the attacked trees previous to the rise of infestation.

Table VIa.--Percent greater radial growth of green trees over attacked trees.

Year of comparison	Number of trees compared: Green	Attacked	Percent greater growth of green trees
Limber Pine			
1936	21	40	33
1937	21	28	48
1938	21	16	93*
10-year period 1929-38	21	43	26
Lodgepole Pine			
1936	23	43	60
1937	23	18	50
1938	23	25	43
10-year period 1929-38	23	43	72

Year of comparison	Mah Keeney Park: No. of trees compared: Green	Attacked	Percent greater growth of green trees	Estes Park: No. of trees compared: Green	Attacked	Percent greater growth of green trees
Ponderosa Pine						
1936	36	57	56	0	0	
1937	36	15	35	43	48	48
1938	0	0		43	27	-3
10-year period 1929-38	36	57	16	43	48	12

*This great difference is possibly due to beetles attacking the trees before growth had been completed for the season.

The cores on which graph I and table VIa are based were taken at random from infested trees and from the green trees nearest to them. An attempt was made to pick the green tree or trees left in a group of dead ones. In no case were green trees picked away from an infestation area, and all the areas from which the cores were taken were considered to be in a serious outbreak condition, i.e., numerous large groups of infested trees (5 to 100) were scattered throughout the area.

The growth data for the infested trees show definitely that the mean growth rate for any given year for ten years preceding the date of attack was less than that of the green trees, and for a ten-year period was never less than 12 percent poorer. There is one exception to the above in ponderosa pine, when in 1938 the mean growth rate of the trees just attacked that year was 3 percent better than the mean growth rate of nearby uninfested trees. These data should be checked by further work this summer, and more attention paid to the size of the infested groups from which the cores are taken, for Blackman (3) points out that he found the average growth rate of ponderosa pine in groups of 6 or fewer to be less than that of the nearby green trees but when more than seven trees are in a group the average growth rate of the infested trees was greater than the nearby green trees. The highly epidemic conditions under which the cores of all three host trees were taken in the present study would indicate that the conditions mentioned by Blackman vary with different infestations. It also appears from these records that although the beetles may select slower growing trees in an area favorable for their development, the area of favorable development is not in the zone of the slowest growing trees.

As with other Dendroctonus this beetle under certain conditions is strongly attracted to freshly hit trees. In 1938 one square foot cages of #16 wire mesh (Figure 3) were tacked on 17 green ponderosa pines. Into each of these cages new adults were added during the flight period. Sixteen of the 17 trees were attacked by the beetles placed in the cage. In most cases only a few attacks were made. Beetles were attracted to 8 of the trees but only five of these were hit heavily enough to be killed. Large numbers of beetles were attracted to the neighborhood of three of these five trees successfully attacked, killing 3, 5, and 6 trees respectively in the immediate vicinity of each of them.

The fact that, although attacks were made in all but one of the 17 cages, only eight of these trees attracted any beetles to them and only five of these attracted beetles in sufficient numbers to make a successful attack indicates that the beetles are attracted to trees only under certain special conditions, even during the heavy flight period. Cores were taken from all of these trees in an effort to determine whether the trees in which no successful attacks could be induced were growing faster or slower than nearby green trees or the trees which were successfully attacked naturally. Unfortunately not enough trees in each category would be found, but Table VIb presents the data that were secured and also data taken at Elk Mountain on the growth of natural pitch-out lodgepole and limber pines.

Table VIb. Average growth, in thousandths of an inch, of green trees, pitch-outs, and attacked trees.

	Basis--number of trees	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938
Limber Pine											
Green trees*	21	30	28	26	26	24	22	19	16	25	29
Pitch-out trees**	5	16	12	13	12	9	7	9	9	14	10
Attacked trees	43	26	24	23	24	24	18	15	12	17	14
Lodgepole Pine											
Green trees*	23	21	18	18	18	16	13	13	11	11	16
Pitch-out trees**	5	9	7	8	8	7	5	5	5	6	8
Attacked trees	45	14	13	12	12	10	8	7	6	7	10
Ponderosa Pine, Wah Keeney Park											
Green trees*	43	24	22	22	16	19	15	16	14	16	25
Pitch-out trees**	15	23	22	25	15	21	16	17	14	16	21
Attacked trees	48	22	19	18	15	15	14	14	11	16	23

* Includes pitch-out trees since these too are still living.

**A pitch-out tree is a green tree which has been unsuccessfully attacked.

There seems to be very little difference in the growth of the green ponderosa and the pitch-out ponderosa pines but there does appear to be a greater average growth for the pitch-out trees than for the successfully attacked trees. The condition for lodgepole and limber pine appears to be quite different for in both cases the natural pitch-outs measured were growing at a slower rate of growth than either the green trees or the attacked trees. It is most probable that an inadequate number of pitch-out lodgepole and limber pine have been secured and more work will be done on this phase next summer.

When taking cores from the trees a record was kept of the condition of the crown, length of needles, and, if successfully attacked, the size of the pitch tubes. As far as can be determined from the scanty data at hand there appears to be no correlation between the type of crown or length of needles and the size of the pitch tubes or susceptibility of certain types of trees. It would seem advisable to follow this line of investigation with sufficient thoroughness to determine whether in this region susceptible trees have external characters that can be used to distinguish them from non-susceptible ones.

PERIOD OF ATTACK

Emergence for all host trees at all elevations seldom begins before the middle of July, and may not start until well towards the end of July. Only a few scattering beetles emerge at first and this is probably caused more by localized or individual conditions than by

conditions obtaining over the entire area. Peak emergence, however, appears to be due to widespread conditions and it occurs at more nearly the same date each year than the first emergence and seems to be more dependent on host tree and elevation. This can best be seen by a study of graph 2. From the data presented in this graph it seems safe to make the generalization that, depending on host and elevation, peak emergence generally occurs within a week of a given date. These dates are shown in table VII.

Table VII.--Approximate date of peak emergence of the Black Hills beetle each year.

Elevation	Tree Species		
	Lodgepole Pine	Limber Pine	Ponderosa Pine
8,000'	August 6	August 3	August 24
9,000'	August 15	August 15	
10,000'	August 25	August 22	

Fall survey work to determine the amount of new infestation should not be begun until the major part of the flight of the beetle is over. The earlier a survey can be started the earlier control work can be instituted when the survey shows it to be necessary. It is therefore important to know the earliest date that such surveys can be started. Table VIII presents the information available on this point.

Table VIII.--Number of days from peak emergence to 95% emergence.

	Tree Species								
	Lodgepole Pine			Limber Pine				Ponderosa Pine	
Year of emergence	1935	1936	1937	1935	1936	1937	1938	1937	1938
Elevation									
8,000'	18(77)*	14(70)		10(78)	11(86)	9(25)	14(73)	9(71)	24(60)
9,000'	15(51)	15(63)	22(37)	9(76)	7(70)	11(24)			
10,000'	17(60)	13(69)	18(68)	16(46)	10(70)	19(66)			

*Number in curves is percent of total emergence up to and including peak-day emergence.

From the information shown in this table one may make the generalization that within certain limits, apparently depending on host and elevation, 95 percent of all beetles leave their trees within a period of time that is more or less constant each year. This period of time is given in table IX.

Table IX.--Average number of days from peak emergence to 95% emergence.

	Tree Species		
Elevation	Lodgepole Pine	Limber Pine	Ponderosa Pine
8,000'	15	11	16
9,000	17	9	
10,000	16	15	

By the use of tables VII and IX one can reach an approximation of the earliest dates on which fall survey work can be started. It also appears that the greater the total emergence at peak-day emergence the fewer the number of days elapsing until total emergence or at least 95 percent of the total emergence is over.

Fall surveys could probably be started quite a bit earlier than the above figures would indicate. During the past season the first new attacks in ponderosa pine stands were found on July 26. By August 6 trees were being hit heavily. Although peak emergence in this area occurred August 23 no more successfully attacked trees were found after August 26. A few new pitch tubes were found on various trees as late as September 20 but in no case did beetles fill in after these first attacks, and these beetles will probably all be pitched out.

It appears from these records that although peak emergence did not occur until as late as August 23 most of these beetles and those emerging after them filled in trees hit by the earlier emerging beetles. Although 16 days elapsed from peak-emergence until 95 percent of the total emergence occurred, no more green trees were hit later than four days after the peak emergence. Fall spotting, then, could be started a week after peak emergence without the danger of any appreciable number of green trees being hit on areas cruised before complete emergence had taken place.

In lodgepole and limber pine the same general condition seems to hold true. The peak emergence in 1938 for limber pine at 8,000 feet occurred on August 15. Green limber or lodgepole pines on which one square foot cages were placed and beetles confined in them in the same way as was explained for ponderosa pine were all first attacked outside the cage before August 15. Five limber pines which had cages placed on them July 30 were all heavily hit, three between August 15 and 20, the two others as early as August 3. None of five green limber pines which had beetles forced into them after August 10 was successfully attacked. In fact in two of the cages the beetles did not even make an attack, and in the other three cases the attacks in the cages were 1, 4, and 5 respectively. Of the ten green lodgepole pine caged August 6 only three were heavily hit, although two more were probably hit hard enough to kill them. These attacks occurred between August 6 and 13, but in the two more lightly attacked trees beetles were still filling in on August 26. It certainly appears from this that it is the first-emerging beetles which select the trees and that practically all the beetles which emerge after peak emergence are absorbed by the trees already attacked. All of these observations should be checked, however, by several more years' study.

HABITS OF ATTACK

Portion of tree attacked.--The midbole of ponderosa pine is generally first attacked by the beetle. Under epidemic conditions beetles fill in above and below these first attacks; above they often go as high as a two or three inch top diameter and into limbs that size and larger; below they extend to the root collar. Under endemic conditions or in apparently declining outbreaks there does not seem to be sufficient beetle population to fill in those trees first attacked, so that the lower and upper thirds of the bole usually remain uninfested. These portions are later filled in by such secondary insects as Ips knausi, I. ponderosae, I. oregoni, I. confusus, I. integer, Dendroctonus barberi, D. approximatus, D. confusus, D. valens, Orthotomicus ornatus, Pityogenes, Acanthocinus, Monochamus, Tetropium, Asemum, and occasionally Melanophila. Because, during endemic conditions, the attacks of the Black Hills beetle do not usually extend to the lower portion of the bole, reconnaissance surveys to determine the presence of the beetle are not satisfactory if checked only by basal examinations. A fair-sized outbreak may build up before it is recognized that the beetle is even in the region unless some trees are either felled or climbed and the mid-portions examined.

Although no figures are available observations by J. A. Beal and subsequent ones by other officials--the treating foremen on both the Roosevelt and Pike National Forests--show that the attacks in

ponderosa pine trees hit during 1938 do not generally extend as far down the bole as they did during the previous three or four years when the lowest two feet of the bole of practically all trees was attacked. These men estimate that this year 60 to 70 percent of the infested trees (1938 attacks) have "white stumps," i.e., have no attacks. Similar observations were made by the writer (5) in Utah on the infestation in Bryce Canyon National Park. In lodgepole and limber pine on Elk Mountain the first attacks are nearer the base but this may be due to the scrubby growth of the trees.

Size of groups attacked.--Another important habit, probably due to heavy local concentrations of beetles rather than to increases in population because of attraction from outside areas, is that of group-killing. The presence of a recently attacked tree appears to be very attractive to beetles in flight, and when there is a heavy beetle population it seems that more beetles are attracted to the tree than there is room for. As will be shown later, the number of attacks per square foot of bark surface increases with the age and probably the population of an infestation. It appears that although the variation in the number of attacks per square foot is quite large there is an upper limit beyond which additional attacks are not made, the beetles preferring to attack green trees rather than ones already heavily hit. It seems that the chief limit to the size of a group of newly attacked trees is the number of beetles available, although as shown previously the slower growing trees in a group of green trees are the ones attacked. Blackman (6) mentions that, generally speaking,

when beetles are present in sufficient numbers to kill seven or more trees in a group an epidemic is present. Table X shows the frequency of the size of the groups of ponderosa pine trees in three areas spotted on the Roosevelt National Forest during the last two years.

Table X.--Frequency of groups of infested ponderosa pine--Roosevelt National Forest.

	Area				
	Magnolia		Elk Ridge-North St. Vrain		Big Elk Park
Year of attack:	1937	1938	1937	1938	1937
Size of group					
1	125	98	213	280	182
2-3	71	29	82	137	60
4-7	25	9	37	68	43
8-15	14	1	16	31	25
16-25	3	0	3	10	8
26-40	0	0	0	0	4
41-60	0	0	0	1	4
61-80	0	0	0	0	1
81-100	0	0	0	0	1
Mean dbh	10.3	11.4	12.0	10.6	10.2

The above table shows definitely that the present outbreak if based on frequency of occurrence of large groups of infested trees shows no noticeable decline. But as mentioned previously the boles of 70 percent to 80 percent of the trees attacked in 1938 are not as extensively hit as in 1937 and smaller trees are being taken so that although there were nearly as many large groups and in some areas more large groups than the previous year there was not the beetle

population in 1938 that there was in 1937. Control work in 1937 and 1938 was not done over the same sections in the areas listed above. This probably accounts for the differences in the mean dbh which would appear to be due to differences in stand composition.

Behavior during attack.--Only one or two observations were made in 1938 on the behavior of the beetle during attack. A rather detailed account of the habits of attacking beetles is given by Blackman (8). During 1938 the writer observed two adults close together on the bark of a tree just being hit. One of these was "singing" and the vibrations of the wing cover could be distinctly seen. The one stridulating was deep in a bark crevice. Although the other beetle was not collected it is probable that it was a female being serenaded by a male. Dissection has shown that only the male has stridulating organs (Fig. 7). Blackman reports hearing similar stridulation coming from under the bark of a newly attacked tree.

It is well known that the female beetle makes the attack and cuts the egg gallery. Mating may take place either before or after the female has entered the bark. In many cases the male follows the female and remains in the egg galleries usually dying there. During the past season C. L. Massey first observed in limber pine three beetles in one gallery; this condition was observed several times after that in this host and also in ponderosa pine. In the only case checked two of the beetles were females, the other a male which was in the gallery between the two females. All three were near the upper end of the gallery.

Attacks per unit area.--The number of attacks per square foot appears to depend chiefly on the beetle population, host tree, and height of attack. Tree diameter and regional differences may also be of considerable importance but their effect has not yet been studied.

Table XI shows the data secured so far.

Table XI.--Number of attacks per square foot made by the Black Hills beetle.

Year of Attack	Tree Species and Locality											
	Elk Mountain, Wyoming								Estes Park, Colorado			
	Lodgepole Pine				Limber Pine				Ponderosa Pine			
	Mean	Min.	Max.	Basis in sq.ft.	Mean	Min.	Max.	Basis in sq. ft.	Mean	Min.	Max.	Basis in sq. ft.
1933-35	11.4	6	25	62	13.2	4	23	50*				
1936	11.5	4	18	32	9.5	4	15	15*	5.6	2	11	92
1937	16.2	5	28	63	17.1	11	23	37	7.4	2	17	102
1938	15.8	8	24	60	17.1	5	28	57	7.2	1	13	85

*based on inadequate number of samples.

The data on which table XI is based were all secured from the basal 6 feet of the trees. The earlier studies for this region (1, 2, and 3) indicate that the greatest number of attacks per unit area for all three host trees occurs in the basal section of the bole. This is shown in table XIa.

Table XIa.--Attacks per square foot according to height of sample.

Tree Species	Year of attack	Height of Sample							
		4-5'	11'	15'	18'	25'	35'	45'	55'
Lodgepole pine	1935	11.5(14)*	7.3(14)		5.8(12)	2.7(6)			
Limber pine	1935	14.2(6)	17.2(6)		12.0(6)	11.5(2)			
Ponderosa pine	1936	6.6(129)		6.0(129)		6.0(92)	5.3(57)	5.3(16)	6.2(8)

*The number in curves is the basis in square feet.

Although these data are not extensive enough in all cases and none were secured for trees attacked in other years it is probable that the trend is indicated except for ponderosa pine, where during endemic conditions one would expect fewer attacks in the basal area.

Subjection of the data on which table XI is based to Fisher's t test showed that there was a highly significant difference between the mean attacks for 1933-36 and 1937-38 for lodgepole and ponderosa pine. This means that there are 99.7 chances out of 100 that the differences are due to a fundamental change in the beetle population or to factors affecting the beetle during those two periods and not to errors in, or inadequacy of sampling. An analysis of variance in the attacks per square foot for the three host trees for 1936, 1937, and 1938 showed that F = 6.72. This thus surpasses the 5 percent point (5.14) for 2 and 6 degrees of freedom, which means that the variation in number of attacks per square foot was due to a difference in the plots, i.e., host trees, and also, within the plots to a change in the character of the population during the three years. One can not say that the increase in the number of attacks per square foot is entirely the result of increase in the beetle population. If such were the case one would expect about as many attacks per square foot in ponderosa pine as in the other two host trees during the height of an outbreak.

Type of attack.--In standing trees, the beetle, in making its attack, generally starts diagonally up across the grain for a distance of a quarter inch or more and then extends its gallery up along the grain. In some cases it starts to the left, at other times to the right. Only occasionally does it start straight up the grain without making the preliminary diagonal gallery. Records were kept during the past season of the direction of these crooks, thinking that possibly there may be a significant difference between the number of right and left ones either because of species of host tree or age of infestation. Table XII shows the data secured on the right and left crook galleries. Straight ones are not shown as they occurred too infrequently.

Table XII.--Direction of gallery crooks.

Year of attack	Tree Species					
	Lodgepole Pine		Limber Pine		Ponderosa Pine	
	Direction of Crook*					
	Right	Left	Right	Left	Right	Left
1933-35	185	157**	138	146		
1936	86	77	--	--	189	113
1937	338	313	188	189	359	332
1938	452	377***	426	357***	217	152***

*A right crook is one with the crook on the right of the long axis of the main gallery.

**Probable that ratio of all galleries from which samples were taken is not 50-50.

***Highly probable that ratio of all galleries from which samples were taken is not 50-50.

Subjection of these data to the chi square test showed that in 1938 for all three host trees chi square was significantly great. This means that the samples counted were almost certainly not from a population with even chances of making a left or a right crook but that there was a decided tendency for some reason or other to make a right crook.

Generally each beetle starts her own attack but two attacks have been observed originating from the same or apparently the same pitch tube. In some cases the crooks extended in the same direction, in other cases one crook was right, the other left. During the past season a few galleries were observed in standing trees that instead of being extended up the grain were extended down the tree. Otherwise they were normal in every way (Figures 4 and 5). It is estimated that about one percent of the galleries are of this type.

Reemergence after attack.--Some work was done by Whiteside (l.c.) in 1935 on parent adult emergence from lodgepole and limber pine and only a small amount more on this phase since then. Whiteside caged limber and lodgepole pine after the attacks were well under way and found considerable emergence as is shown by table XIII.

Table XIII.--Parent adult emergence

Tree Species	Square feet of bark caged	Parent Adults emerging	Average Number per square ft.	Attacks* per sq.ft.
Lodgepole pine	14	39	2.7	11.4
Limber pine	16	50	3.1	13.5

*Average for all trees. Attacks per square foot for cages under consideration not known.

Although the sexes were not separated one can arrive at an approximation of the per cent reemergence if one assumes that 80 percent of the galleries are occupied by females only, as is shown below for ponderosa pine. If this is assumed, then slightly less than 20 percent of the attacking beetles reemerged.

When making attack counts on ponderosa pine killed in 1938, records were kept on three trees of the number of emergence holes per square foot and whether any beetles were in these galleries with emergence holes. These data are summarized in table XIV.

Table XIV.--Ponderosa pine. Parent adult emergence as of September 28 and 29, 1938.

Tree No.	Height of sample (in feet)	No. of sq.ft. Measured	No.of P.A. Emergence holes	P.A. emergence holes per sq. ft.	No. of galleries with both emergence hole and beetle	Galleries with dead or living beetles but with no emergence holes			
						Living Beetles Number of galleries		Dead Beetles Number of galleries	
						with 1 beetle	with 2 beetles	with 1 beetle	with 2 beetles
5	2	2	0	0.0	0	11	1	0	0
	3	2	1	0.5	0	8	8	0	0
	4	3	7	2.0	1	15	4	0	0
	5	3	9[a]	2.7	1	7	3	0	0
	6	3	10	3.0	1	9	2	1	0
	7	3	7	2.3	0	11	2	1	0
	8	3	9	3.0	0	13	2	0	0
	9	3	11	3.9	2	12	3	0	0
14c	2.5	3	2	0.7	0	10	1	3	½*
	3.5	3	13	4.3	0	7	0	1	0
	4.5	3	9	4.5	0	7	0	2	0
	5.5	2	4	1.3	0	7	2	0	0
14f	1	2	0	0.0	0	0	1	0	0
	2	2	1	0.0	1	11	2	5	1**
	3	2	0	0.0	0	11	2	1	½*/
	4	2	1	0.5	0	13	2	1	0
	5	2	6	2.5	1	9	2	0	0
	6	1	9	9.0	0	1	2	1	0
	7	1	8	8.0	0	1	0	0	0
	8	1	3	2.0	1	0	0	0	0
Totals		46	110	2.2 (aver.)	8	163	39	16	3

[a]Two emergence holes in one gallery.
*½ means two beetles in gallery but one of them dead. In all cases it was the male that was dead.
** In gallery 9" long.
/ Both beetles in middle of gallery and back beetle alive.

Table XIV shows that of 330 galleries in 46 square feet of bark examined September 28 and 29, 1938, 109 of them, or 33.1 percent, were already abandoned; that of the remaining 221 galleries which contained beetles and which were without as yet any parent adult emergence holes, 80.9 percent contained but a single beetle. This shows that even as early as the date of examination there was considerable parent beetle emergence and that, if one considers the ratio of the galleries with one and two beetles left in them to be indicative of the ratio as a whole before any emergence occurred, then over 80 percent of the galleries are inhabited by females only. Whether this is a normal occurrence and whether these emerging beetles will reattack will be checked by further studies this year.

Emergence holes were found August 29 on a tree first attacked August 2 and by the middle of September they were fairly numerous. As no newly attacked trees were found after August 26 it seems likely that these reemerging beetles fill in trees already attacked so that while they may be a factor in brood increase they will not be a factor in estimating the number of newly attacked trees in fall survey work. Work will be done next season to determine the percent of these reemerging beetles that will make a second attack, and how many eggs they will lay.

The egg gallery.--The length of the egg gallery was found to vary not only with the tree species in which the gallery was constructed but to some extent with the number of attacks per square foot. Inasmuch as the number of attacks per unit area was found to vary significantly for both host and year of infestation this variance in gallery length may not be directly due to the host tree and the year of construction but indirectly, as a function, to the number of attacks per unit area. Table XV shows the data secured so far.

Table XV.--Gallery lengths, in inches, of the Black Hills beetle, Elk Mountain, Wyoming.

Year of attack	Tree Species: Lodgepole Pine: Mean	Min.	Max.	Basis (# of galleries)	Limber Pine: Mean	Min.	Max.	Basis (# of galleries)	Ponderosa Pine: Mean	Min.	Max.	Basis (# of galleries)
1935	10.2*	1°	26.4	475	7.0	1°	20.9	408				
1936	12.9	1	29.5	180	9.2	1	27.8	153	13.9	1°	32.2	512
1937	10.8	1	24.1	239	10.0	1	19.3	106	14.8	1	33.1	711
1938									13.8	1	29.2	218

° Galleries less than 1" long were considered to be pitch outs. Galleries of 1" were found for all three host trees in each of the years measurements were made.

*Also includes 1934 data.

Gallery lengths in ponderosa pine attacked in 1938 were measured late in October and early in November of that year. As the mean gallery length in 1938 was intermediate to that of 1936 and 1937 it would seem that gallery extension is practically completed before winter sets in.

In ponderosa pine there appears to be a downward trend in the mean gallery lengths as the number of attacks increases. Graph 3 shows this trend to be quite pronounced but statistical analysis of the data showed that differences are not in all cases significant. The difference in the mean lengths of galleries where the attacks average from 1 to 4 per square foot and the mean lengths of galleries where the attacks average 11 to 12 per square foot is highly significant. In fact between galleries where the attacks average 9 to 10 and 11 to 12 per square foot there is a highly significant difference. For lodgepole there is also a trend downward but for limber pine no definite trend is discernible. Table XVI summarizes the data secured so far.

Table XVI.--Mean gallery lengths, in inches, according to density of attacks.

	Tree Species							
	Lodgepole Pine			Limber Pine			Ponderosa Pine	
Year of attack:	1934-35	1936	1937	1934-35	1936	1937	1936	1937
Attacks per square foot:								
1-2							17.5	13.7
3-4							14.6	16.4
5-6		17.0					12.5	16.6
7-8	13.2	14.8	11.0		10.1		13.0	14.8
9-10	9.4	14.4	10.3	8.7	10.2		11.6	14.1
11-12	11.4	12.9	11.6	7.3	--	6.4	8.3	13.6
13-14	10.5	11.2	11.9	6.8	9.7	10.1	--	--
15-16	13.6	--	11.5	--	--	9.5	--	--
17-18	7.9	10.9	10.7	7.8	--	10.4	--	--
19-20	--	--	10.5	8.0	--	9.0	--	--
21-22	6.9	--	8.3	7.4	--	8.5	--	--
23-24	7.2	--	9.1	7.7	--	9.4	--	--
Mean	10.2	12.9	10.8	7.0	10.0	9.2	12.9	14.8
Basis in galleries	475	180	239	408	105	153	512	711

The female makes numerous turning niches during the construction of her egg gallery. Counts of the turning niches in two galleries in ponderosa pine were made; in one gallery 22½ inches long 15 turning niches were present, in another 20 5/8 inches long there were 12 turning niches.

No counts were made of the number of eggs laid per female. In ponderosa pine it was observed that most of the eggs were laid in loose groups of from two to four but occasionally only a single egg is laid; the groups are about an inch apart though often closer together than that.

Variation in galleries.--As mentioned previously the female beetle generally extends her gallery up the tree in the direction of the grain of the wood. On approaching a gallery of another beetle she usually changes the direction of her gallery to avoid crossing the other, thus cutting across the grain contrary to general rule. That the tendency of the beetle is to follow the grain rather than a vertical direction seems to be indicated by galleries close to knots and on trees with spiral grain. All galleries observed close to knots follow the grain as it bends around the limbs rather than continuing vertically, even though if continued in that direction it would not touch the limb. When the grain of the limb is continuous with that of the trunk, the beetle usually continues her gallery out into the limb. In trees with spiral grain the galleries almost invariably follow the grain. Sometimes, however, a beetle, instead of

going around another attack, chews its way out and leaves the tree. Beetles do not leave the tree only because of interference, for empty galleries have been observed with no other galleries near them.

At other times instead of turning and going around an attack above her or chewing her way out and abandoning the gallery the beetle will reverse herself and go down the tree. The beetles seem to be able to sense when they are in the vicinity of the gallery of another beetle for they begin to turn out or reverse themselves before they come in contact with the other gallery. They may often be an inch or more away from the gallery above them at the time they start to change their gallery direction.

The female does not always turn out for a gallery ahead of her. Sometimes she will continue right through a crook of another gallery or even in another egg gallery for some distance so that a section of the two galleries is common. It would thus be possible to find two females in what appears to be a single gallery but which if further examination were made would prove to be two galleries. Figure 8 shows a series of sketches made in the field of these various types of gallery peculiarities.

NEW ADULTS

Feeding habits.--After transforming to the adult the beetle remains under the bark for a considerable period before emerging. By

the middle of July and often earlier most of the brood in all three host trees is in the new adult stage but as is shown by the emergence records they usually do not start to leave the tree in any numbers until after August 1. Emergence from limber and lodgepole pine at 8000' elevation is earlier than for the higher elevations; major emergence usually starting the last week in July.

During the period between transformation to the adult and emergence, considerable "feeding" is done by the beetles. They usually chew away so much of the remaining phloem that several pupal cells are united. Occasionally a half dozen or more beetles may be observed congregated together. Whether the beetles do any actual feeding is not known, although a certain amount of feeding by the beetles may be necessary before they can reach sexual maturity.

Sex ratio.--When making counts of the new adult Black Hills beetles trapped in the tree cages during the past season each specimen was separated according to sex. This was done by lifting the elytra and checking on the shape of the dorsum of the last two abdominal segments. The male has a large oval pygidium; that of the female is smaller and less heavily sclerotized. The caudal margin of the propygidium of the male bears a bifid rasping organ, and is strongly sclerotized; the caudal margin of the female propygidium lacks this bifid process and is not reinforced. A rough sketch of these characters is shown in figure 7.

Besides the separation according to sex of the specimens collected the past season a representative number of specimens collected from tree cages the previous year from ponderosa pine and from limber and lodgepole pine were separated according to sex. The results are shown in table XVII.

Table XVII.--Sex ratio of emerging new adult Black Hills beetles.

Year of Emergence	Tree Species: Lodgepole (1) Males	Lodgepole (1) Females	Limber Attacked 1936(2) Males	Limber Attacked 1936(2) Females	Limber Attacked 1937 Males	Limber Attacked 1937 Females	Ponderosa Males	Ponderosa Females
1937	203	297					211	289
1938			75	84	357	437	323	510
Sex ratio	1:1.46*		1:1.12**		1:1.22***		1:1.37*	1:1.58*

*Chi square highly significant--samples definitely not taken from a population with a 50-50 ratio.

**Chi square not significant--samples may have been taken from a population with a 50-50 ratio.

***Chi square significant--samples probably taken from a population with a 50-50 ratio.

(1) Also includes beetles from limber pine.

(2) Second-year emergence.

The data on which table XVII is based were subjected to the standard test for the determination of the probability of the samples coming from a population in which it was assumed that the sexes occurred in equal numbers. The table shows that in only one case does

it appear that the sex ratio of the beetle was 50-50. In this one case it is probable that an insufficient number of beetles were secured.

It will be noted that the ratio of females to males from ponderosa pine was slightly greater in 1938 than in 1937. It appears to be true of the insects as well as of many other animals that have been studied that a decrease in food supply causes an increase in the number of males. If this were true for the Black Hills beetle in ponderosa pine it would appear that the number of attacks and thus the amount brood per square foot in 1937 was not enough to reduce seriously the food supply of the developing larvae. Unfortunately we have no record of the sex ratio for the three host trees over a period of years to enable one to investigate this field more thoroughly.

Emergence per square foot as determined by collections from the tree cages has declined steadily. This is shown in table XVIII.

Table XVIII.--New adult emergence per square foot.

Year of Emergence	Average Emergence per Square Foot--All Elevations					
	Lodgepole Pine	Sq.Ft. of Bark Caged	Limber Pine	Sq.Ft.of Bark Caged	Ponderosa Pine	Sq.Ft.of Bark Caged
1935	18.2	32	164.5*	28	--	--
1936	51.9**	40	89.1	32	--	--
1937	19.7	40	88.1	60	28	80
1938	--	--	66.9	12	21.5**	40

*Does not include second year emergence which would bring the average up to 174 beetles. For second year emergence see table XXI.

**This average should be slightly higher as four vials were lost from one day's collection on July 26, 1938.

The data in the above table would certainly indicate that the infestation is on the decline.

Emergence.--Just what the conditions must be which start the general exodus from a tree is not known but it seems possible that the "feeding" period between transformation and emergence gives backward brood or brood from later laid eggs a chance to catch up with the more advanced brood. Most of the beetles attacking a tree are jet black but it is not at all uncommon to uncover beetles with reddish-brown wing covers in recently attacked trees. These beetles with the lighter colored elytra may be from the backward brood mentioned above and if so this feeding period does tend to concentrate the emergence period. During 1938 it was found that callow adults which were still yellowish would, when confined in a tree cage, attack the tree within a day or so after being placed in the cage.

When the beetles are ready to emerge it seems that one of them, where several have grouped together, takes the initiative and bores the emergence hole, the others following after. Counts made of new adult emergence holes and total brood emerging indicate that from limber pine more beetles emerge from the same emergence hole than from ponderosa or from lodgepole pine. In checking over the records on this point a disturbing number of cases were found where the number of emergence holes exceeded the number of beetles emerging. Some error in the notes, lost notes, poorly put on cages, or undiscovered habit of the beetles must be the cause of this discrepancy. Because of this discrepancy table XIX summarizes data only on those cages in which the beetles emerging exceeded the number of emergence holes and being selected data should not be considered of much value.

Table XIX.--Ratio of emerging new adults to new adult emergence holes

Tree Species											
Lodgepole Pine			Limber Pine			Ponderosa Pine					
Based on four square feet for each tree except as noted.											
Tree No.	Total beetles Emerging	Emergence holes	Tree No.	Total beetles Emerging	Emergence Holes	Tree No.	Total beetles Emerging	Emergence Holes			
1	130	116	4	791	199	2*	61	35			
8	123	46	9	700	297	3	53	33			
15*	24	18									
18	231	105	10	403	124	4	50	169			
19	169	139	13	665	150	5	243	103			
	677	424	14	711	80	8*	98	44			
Ratio 1.6:1			16*	130	51	9	226	128			
			17	532	166	11*	71	39			
			20	269	145	13*	81	31			
			22	332	83	16	122	55			
			23	401	93	17*	42	12			
			25	417	101		1047	649			
			26	201	131		Ratio 1.6:1				
			31*	272	39						
				5824	1659						
				Ratio 3.5:1							

*2 square feet

Dispersion of beetles.--On July 27, 1938 Massey and Keller put cages on three green ponderosa pine growing with about 300 other trees on an isolated knoll. These cages were of the same type shown in photo 3 but larger. It was estimated that the nearest timber to this knoll is about 15 miles to the northeast. Elk Mountain is about 20 miles to the south with apparently no timber between the two areas. Medicine Bow, about six miles to the southeast, is the town nearest to this area.

Tree number one and two each had 90 beetles placed in the cages and tree number three 200 beetles. The beetles, which were added the same day the cages were erected, had been counted previously. A small opening was left at the top of the cages, the vial of beetles emptied through the opening and the opening immediately nailed up.

When next examined on August 3, three attacks were found outside the cages on tree number two near the base. The galleries were not examined and the attacks may have been made by D. valens. No new attacks were found on August 10, but on August 19, the date of the next examination, two new attacks were found on tree number three. Fairly heavy attacks were made inside all three cages.

It is possible that the beetles may have bored out under the wire stripping, and made their attacks in the trees after escaping but this does not seem at all likely. This point can be checked, however, by examination next spring. Until a final examination is made it is felt that no definite statement can be made as to whether beetles flying into the area or escaped beetles made the attacks outside the cages.

DEVELOPMENTAL PERIOD

Observations made so far indicate that in ponderosa pine at any elevation there is only one generation a year of the Black Hills beetle. In lodgepole and limber pine at elevations of about 8,000 feet there is usually but one generation a year. In 1936 it was discovered for both of these host trees that at higher elevations (about 9,000 feet and over) the beetle sometimes took two years to develop and in 1937 it was found that also at 8,000 feet some beetles took that long to develop. Second-year emergence at the higher elevations has been found to occur every year since then. Even trees from which there was considerable first-year emergence contained brood which did not transform and emerge until the second year after the tree was attacked.

Table XX shows the frequency of second-year emergence from the trees caged at Elk Mountain.

Table XX.--Frequency of second year emergence.

Tree Species and Elevation	1936	1937	1938
Limber Pine			
8,000'	0 out of 2 trees	2 out of 3 trees	0 out of 4 trees
9,000'	2 out of 2 trees	1 out of 2 trees	3 out of 4 trees
10,000'	3 out of 3 trees	3 out of 3 trees	3 out of 8 trees
Lodgepole Pine			
8,000'	0 out of 3 trees	0 out of 3 trees	---
9,000'	0 out of 3 trees	1 out of 1 tree	2 out of 4 trees
10,000'	2 out of 2 trees	2 out of 2 trees	4 out of 5 trees

This looks as though second-year emergence is a rather important factor and that in control work trees two years old will have to be checked. This would be necessary perhaps the first year that control work was done in an area but the treating of that year should have eliminated all those trees so that only newly attacked trees would have to be considered in the spotting work of the following year. Second year emergence is not very heavy. Table XXI shows the emergence from second-year trees the first and second year after being attacked.

Table XII.--Second year emergence by the Black Hills beetle.

Tree Species																			
	Lodgepole Pine										Limber Pine								
Year of attack:			1934		1935		1936				1934		1935		1936				
Year of emergence			1935	1936	1936	1937	1937	1938			1935	1936	1936	1937	1937	1938			
Elevation in ft:	Tree No.	Sq. ft.							Tree No.	Sq. ft.									
8,000									25	4*			150	1					
									29	4			514	4					
													664	5					
Percent total emergence													0.7						
9,000	30	4			124	87			9	4*	343	2							
	43	4					82	3	10	4	200	26							
	45	4*					50	1	22	4*			146	1					
									36	4*					5	1			
									44	4					242	10			
									49	4*					738	1			
					124	87	82	4			543	28	146	1	985	12			
Percent total emergence					41.2		4.7				4.9		0.7		1.2				
10,000	11	4	217	10					12	4	942	67							
	15	4*	23	1					13	4	614	50							
	18	4			208	23			14	4	575	126							
	19	4			158	13			16	4*			83	47					
	35	4					32	12	17	4*			40	2					
	52	4*					162	20	20	4			247	15					
	53	4					95	77	32	4*					280	42			
	54	4*					174	5	33	4*					611	25			
									55	4*					172	4			
			240	11	366	36	468	114/			2131	243	730	64	1033	71**			
Percent total emergence			4.4		9.0		19.8				10.2		8.1		6.4				

*2nd yr. emergence from only 1 side of tree.
**39.8% of these were males.
/ 50% of these were males.

This table shows that for the most part less than ten percent of the total emergence is made up by second-year beetles.

As in 1937, second-year emergence in 1938 was found to extend over approximately the same period as did the first-year emergence. This is shown by table XXII.

Table XXII.--Black Hills beetle emergence at Elk Mountain, 1938.

Tree Species	Date of Collection: July 18	July 25	July 28	August 1	August 2	August 4	August 8	August 10	August 12	August 16	August 20	August 23	September 10	Total
LIMBER PINE														
First year emergence			193	397	55	32	--	32	17	64	10		8	808
2nd year emergence	2	7					51					20	4	84
LODGEPOLE PINE														
2nd year emergence	2	11					88					15	3	119

Records of emergence in 1937 disclosed that a few beetles had been collected from trees attacked three years previously. No third-year beetles were found in 1938 and it is probable that those beetles which were collected in 1937 had emerged the previous year but had died in a bark crevice or had become caught in the screen and did not fall into the collection jars until the following season.

SUMMARY

1. The Black Hills beetle is known to attack and rear broods in six species of pine and two species of spruce. It has also been collected from Douglas fir and Alpine fir but no successful attacks were made. In the Rocky Mountain region the three principal host trees are Pinus flexilis, P. ponderosa, and P. contorta. These are the only trees dealt with in this report. Largest broods are found in P. flexilis. p. 5.

2. Beetles reared from ponderosa pine were found to be larger than those from limber pine, and those from limber pine larger than those from lodgepole pine. pp. 5-6.

3. In stands of mixed lodgepole and limber pine the beetles appear to select limber pine if under 18" dbh but over this size no host preference seems to be shown. pp. 9-10.

4. In stands of lodgepole and limber pine where all trees above 6" dbh were tallied the mean diameter of infested trees of both species is greater than the mean diameter of the non-infested trees. pp. 11-13.

5. As the infestation continues the beetles seem to select smaller and smaller trees but still those trees selected are above the mean dbh of non-infested trees. p. 13

6. The growth rate of green trees for all three species during the year of attack and for the average of the preceding 10 years was, with one

exception, always 12 percent or more than the nearby infested trees. The one exception was in ponderosa pine when the infested trees measured in 1938 were found to be growing somewhat faster than the nearby non-infested green trees, and in 1937 when the growth of the green trees was 6 percent better than the infested trees. pp. 14-18.

7. Infested ponderosa pine are rarely found below 7500 feet elevation although in this region the lower limit for their growth is at about 5600 feet elevation. There is about two inches greater precipitation at the higher elevation. p. 14.

8. Peak-emergence of the beetle during the past four years was found to vary with elevation and host tree but to be more or less constant for a given host and elevation. Emergence of the beetle from ponderosa pine at 8,000 feet elevation occurred about the same time as for lodgepole and limber pine at 10,000 feet elevation. Date of peak-emergence was found to be more constant than date of first emergence. pp. 19-23.

9. Selection of trees seems to be made chiefly by the first emerging beetles; very few newly attacked trees were found after peak-emergence. Those beetles emerging at that time and later appear merely to fill in the trees already attacked. p. 23.

10. In ponderosa pine in 1938 the infestation did not extend as far down the bole of the tree as frequently as in previous years. pp. 24-25.

11. In ponderosa pine there appears to be, as yet, no appreciable decline in the size of the groups of infested trees or their frequency. pp. 25-27.

12. Attacks per square foot in 1937 and 1938 were significantly greater for all three host trees than in 1936 or, where data were available, in 1935. pp. 28-30.

13. In a given year, on the average, the greater the number of attacks per square foot, the shorter the gallery lengths. The average gallery lengths in 1937 were as follows: lodgepole pine 10.8"; limber pine 10.0"; ponderosa pine 14.8". pp. 38-39.

14. There appears to be a significant difference in the number of attacks per square foot for each of the three host trees; in 1938 they averaged as follows: lodgepole pine 15.8; limber pine 17.1; ponderosa pine 7.2. pp. 28-30.

15. In 1938 there were significantly more right-crook galleries than left-crook ones per square foot for all three host trees. pp. 33-34.

16. There appears to be an appreciable amount of parent-adult re-emergence for all three host trees. In ponderosa pine about 33 percent of the females were found to abandon their first galleries; for the other two species it is estimated to be about 19 percent in 1935, the only year studies were made on this point. pp. 34-37.

17. Data secured for ponderosa pine in 1938 showed that about 80 percent of the galleries are occupied by the female beetle only. p. 37.

18. In standing trees although the beetle in general makes, after the initial crook, a straight gallery up the grain of a tree, considerable variation from this habit has been observed. In some cases the beetle goes down the grain; in other cases it may make a branched gallery. pp. 41-42.

19. In ponderosa pine for 1937 and 1938 there was a highly significant greater number of females than males; in limber pine in 1936 and 1937 the differences were not significant, and significant respectively. The ratios were as follows: ponderosa pine--1937, 1:1.37; 1938, 1:1.58; limber pine--1937, 1:1.22. pp. 43-45.

20. New-adult emergence per square foot was less for limber and ponderosa pine in 1938 than in 1937. pp. 45-46.

21. In both limber and lodgepole pine, especially at elevations above 8,500 feet, some beetles require two years to develop. This is true even in the same bark area, for in some cases nearly as much brood was collected from the same tree cage the second year after attack as the first year. No second-year emergence has been found to occur in ponderosa pine. pp. 49-52.

References

1. Progress report of a study of the Black Hills beetle emergence in southeastern Wyoming, summer of 1935. By J. M. Whiteside. Fort Collins, Colo. 1936. MS.
2. Progress report of a study of the Black Hills beetle emergence in southeastern Wyoming, summer of 1936. By J. M. Whiteside and J. A. Beal. Fort Collins, Colo. 1937. MS.
3. Progress report of a study of the Black Hills beetle in southeastern Wyoming and central Colorado, summer of 1937. By J. A. Beal and Donald De Leon. Fort Collins, Colo. 1938 MS.
4. List of fauna associated with the Black Hills beetle in ponderosa, lodgepole, and limber pine. By Donald De Leon. Fort Collins, Colo. 1939. MS.
5. Memorandum on the insect situation in Bryce Canyon National Park, Utah. By Donald De Leon. Fort Collins, Colo. 1938. MS.
6. The genus Dendroctonus. By A. D. Hopkins. USDA Tech. Series No. 17. Part I. 1909.
7. Report on an examination of Dendroctonus ponderosae and D. monticolae. By M. W. Blackman. Washington, D. C. 1938. MS.
8. The Black Hills beetle, Dendroctonus ponderosae Hopk. By M. W. Blackman. Tech. Publ. 36. N.Y.S. College of Forestry, Syracuse, N. Y. 1931.

Figure 1

Type of cages used to secure emergence data on the Black Hills beetle and the fauna associated with it. Cages made of #18 mesh copper screen tacked to tree with box binding. Honey-sample jars hold the preservative.

Figure 2

Type of cages used in host selection study.

Figure 3

Type of cage used in confining Black Hills beetle on green trees to induce outside attacks. Cage 1 sq. ft. of #16 galvanized wire.

Figure 4

Galleries of the Black Hills Beetle in Limber Pine.
1938 attack.
Arrows point to two galleries extended down the tree.

Figure 5

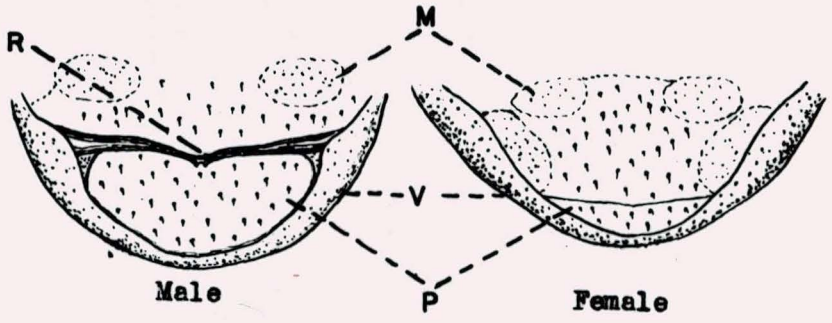
Galleries of the Black Hills beetle in ponderosa pine. 1936 attack. Arrow 1 points to gallery extended down the tree; arrow 2 points to two galleries apparently started from same point of attack.

Figure 6

Elk Mountain, Wyoming looking eastward.

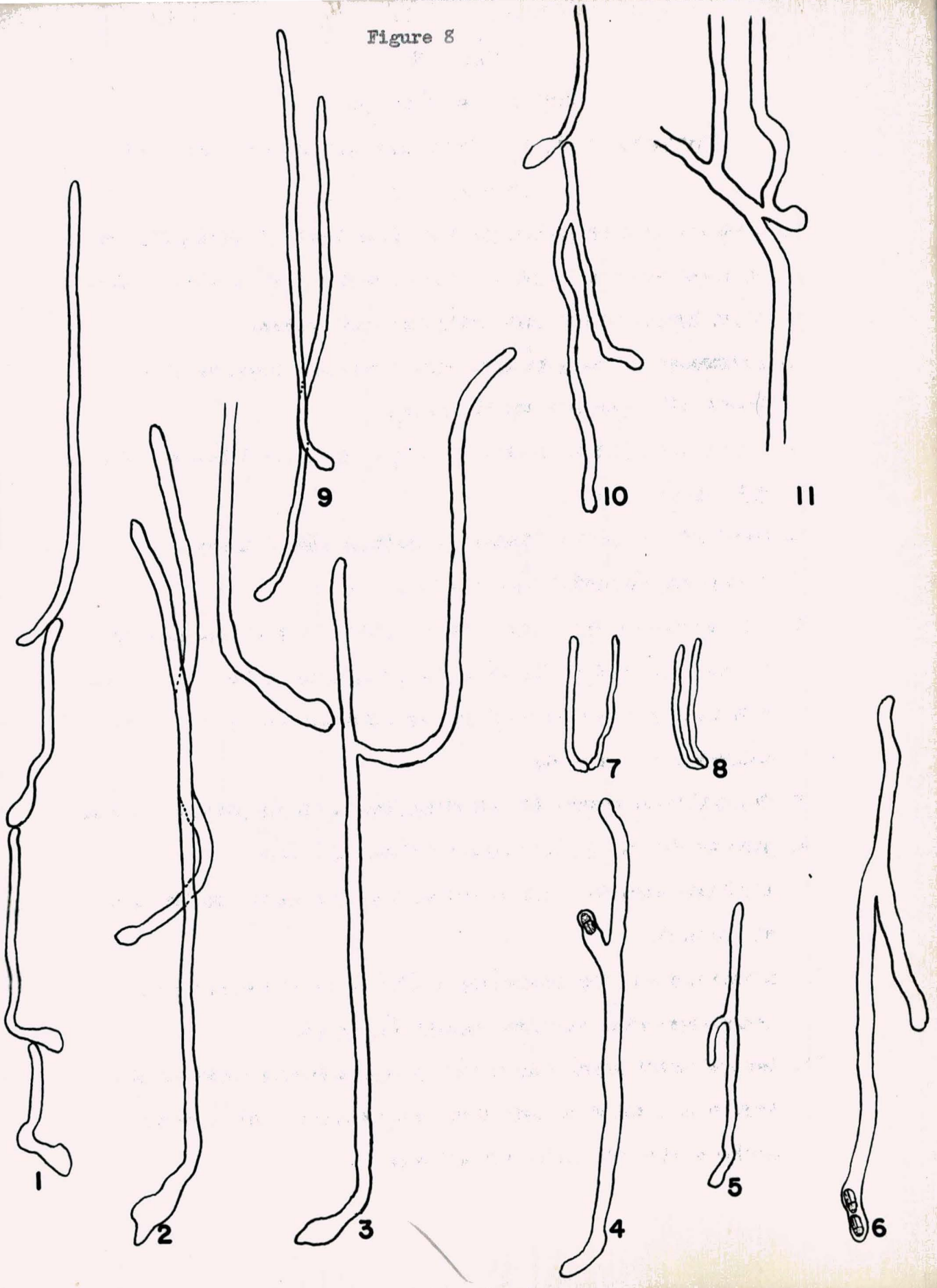
Figure 7

Dorsal view of last two segments
of abdomen of the Black Hills
beetle
(Elytra removed)

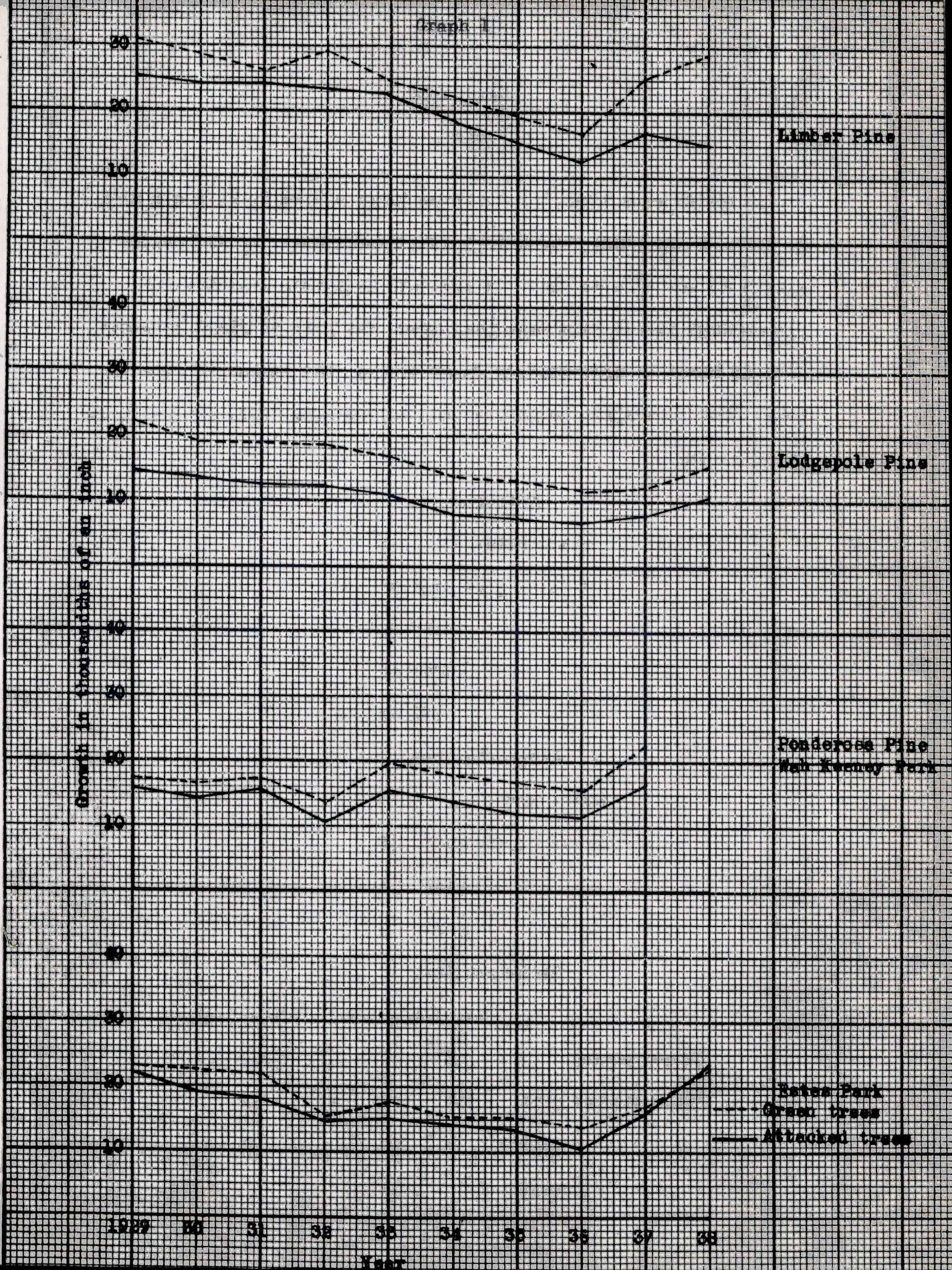


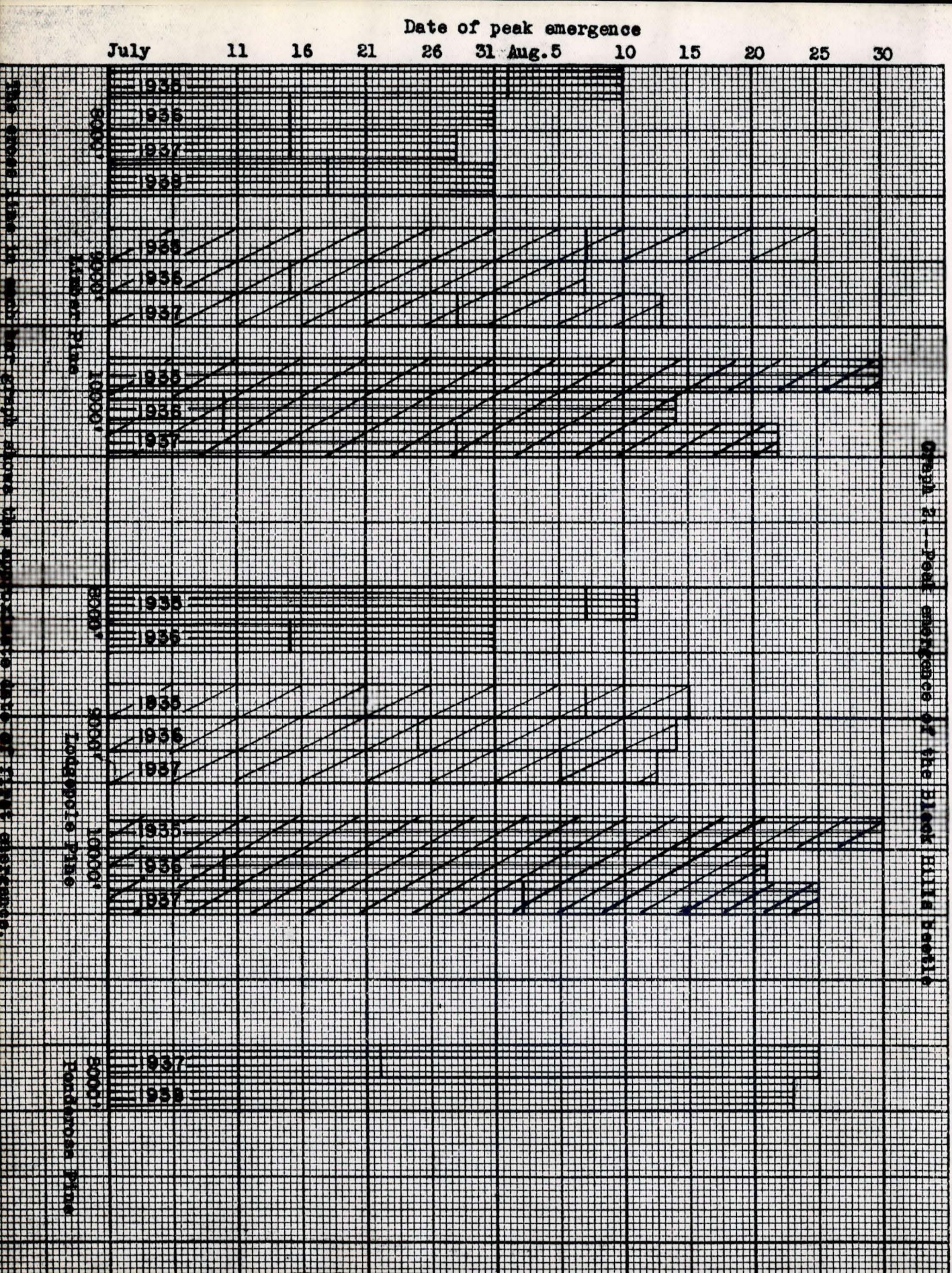
M - Membranous lobe
P - Pygidium
R - Rasp
V - Venter

Figure 8



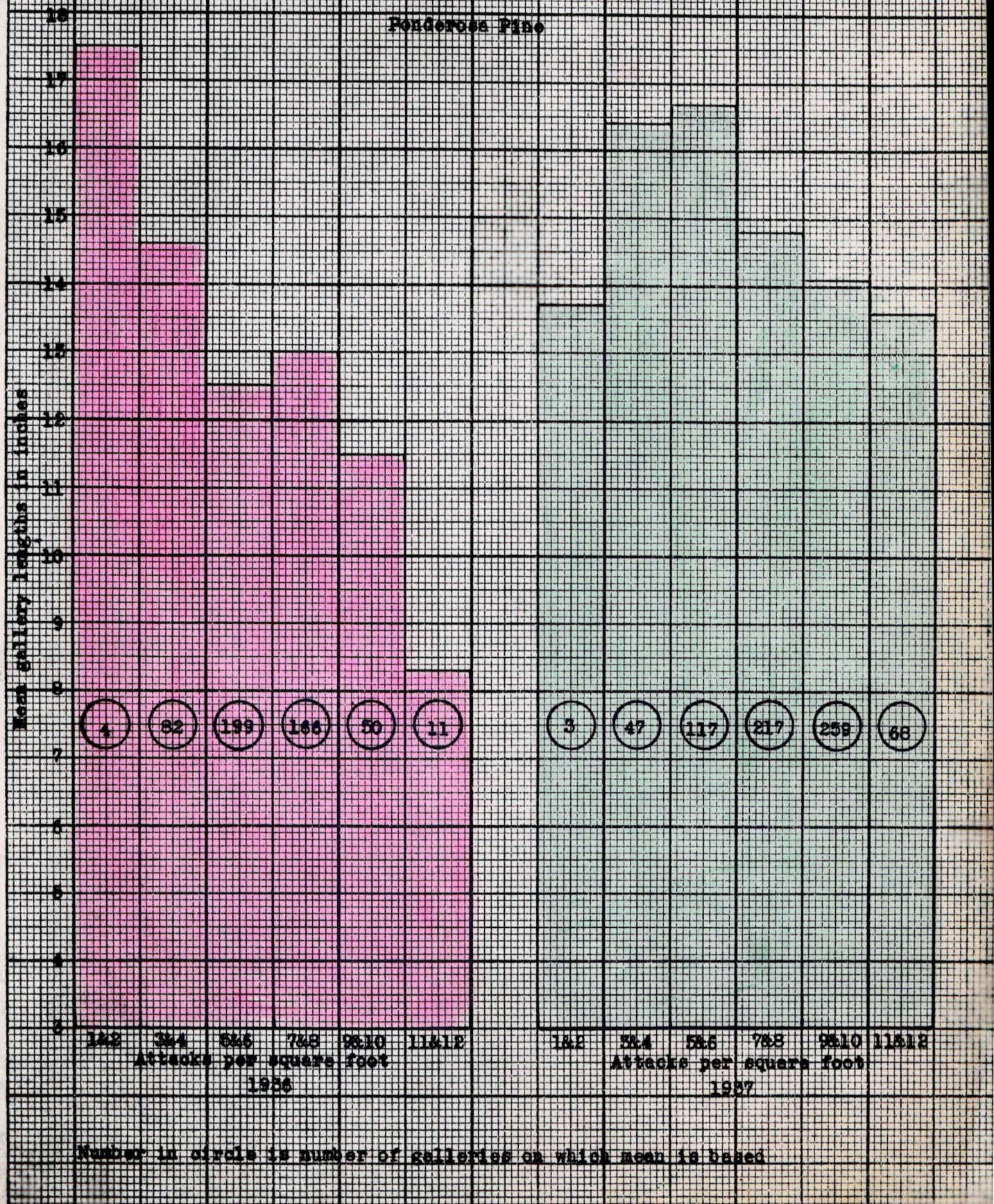
Graph 1


Limber Pine
Lodgepole Pine
Ponderosa Pine
Mah Kwaney Park
Estes Park
Green trees
Attacked trees
Number in thousands of trees
Year
1929
30
31
32
33
34
35
36
37
38


Date of peak emergence
July
11
16
21
26
31
Aug. 5
10
15
20
25
30
1935
1936
1937
1938
Early Plots
Late Planted Plots
Resistant Plots
Chart 2.--Peak emergence of the Black beetle

Graph 3.--Relation of gallery length to attacks per square foot

Ponderosa Pine



APPENDIX

Table I.--Emergence of the Black Hills beetle from caged limber pine; 1938 emergence from 1937 hit trees.

	Limber Pine		Ponderosa Pine	
	8,000 Feet Elevation		8,000 Feet Elevation	
	North Cage	South Cage	North Cage	South Cage
	#58 - 24	#58 - 262	#1 - 86	#1 - 62
	59 - 151	59 - 89	2 - 3	2 - 6
	60 - 187	60 - 90	3 - 7	3 - 14
			4 - 141	4 - 15
			5 - 18	5 - --
			6 - 75	6 - --
			7 - 17	7 - 33
			7-25' - 61	7-25' - --
			8 - 137	8 - 57
			9 - 3	9 - --
			10 - --	10 - --
			11 - 58	11 - 48
			12 - 13	12 - 7
Emergence	362	441	619	242
Square feet of bark caged	6	6	24	16
Emergence per square foot	60.3	73.5	25.7	15.1
Total emergence	803		861	
Total sq. ft. of bark caged	12		40	
Emergence per square foot	66.9		21.5*	

*This average is slightly lower than it should be as one day's collection from 4 trees was lost on July 26, 1938.

APPENDIX

Table II.--Emergence of the Black Hills beetle from limber pine, 1938, at an elevation of 8,000 feet.

North Side

Date of Collection	Tree No. 58		Tree No. 59		Tree No. 60		Total		
	Male	Female	Male	Female	Male	Female	Male	Female	Both sexes
July 26	Cages erected and some emergence already begun								
28	3	6	9	29	22	29	34	64	98
Aug. 1	2	4	38	21	45	50	85	75	160
2	2	2	5	1	7	3	14	6	20
4	1	1	0	1	4	4	5	6	11
12	0	0	2	2	9	11	11	13	24
16	0	0	15	20	0	0	15	20	35
20	0	0	2	0	0	1	2	1	3
Sept. 10	1	0	1	1	2	0	4	1	5
Total	9	13	72	75	89	98	170	186	356*

* + 6 specimens sex of which is undeterminable.

South Side

July 26	Cages erected and some emergence already begun								
28	16	26	17	26	3	7	36	59	95
Aug. 1	82	98	4	2	17	34	103	134	237
2	3	4	9	8	3	6	15	20	35
4	2	3	6	8	1	1	9	12	21
12	0	1	4	1	6	6	10	8	18
16	11	14	0	0	0	0	11	14	25
20	0	0	0	1	3	1	3	2	5
Sept. 10	0	2	0	0	0	0	0	2	2
Total	114	148	40	46	33	57	187	251	438*

* + 3 specimens sex of which is undeterminable.

APPENDIX

Table III.--Emergence of Black Hills beetle from limber pine. Six cages for a total of 12 square feet. Elevation 8,000 feet.

Collection Date	North Cages				South Cages			
	Total Dp	Percent of total	Total to date	Percent of total to date	Total Dp	Percent of total	Total to date	Percent of total to date
July 28	98	27.1	98	27.1	95	21.5	95	21.5
Aug. 1	160	44.2	258	71.3	237	53.7	332	75.2
2	20	5.5	278	76.8	35	7.9	367	83.1
4	11	3.0	289	79.8	21	4.8	388	87.9
12	27	7.4	316	87.2	21	4.8	409	92.7
16	37	10.3	353	97.5	25	5.7	434	98.4
20	3	.8	356	98.3	5	1.1	439	99.5
Sept. 10	6	1.7	362	100.0	2	.5	441	100.0
	362				441			

APPENDIX

Table IV.--Combined total of Black Hills beetle emergence from north and south cages--limber pine, 1938. Elevation 8,000 feet.

Collection Date	Number Dp.	Percent of total	Total to date	Percent of total to date
July 28	193	24.0	193	24.0
Aug. 1	397	49.5	590	73.5
2	55	6.8	645	80.3
4	32	4.0	677	84.3
12	48	6.0	725	90.3
16	62	7.7	787	98.0
20	8	1.0	795	99.0
Sept. 10	8	1.0	803	100.0
	803			

APPENDIX

Table V.--Emergence of the Black Hills beetle from ponderosa pine, 1938. North cages.

Collection Date	Tree Number 1		2		3		4		5		6		7*		8		9		11		12		Totals	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
July 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
26	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	1	1	0	3	3
Aug. 2	2	2	0	0	1	0	0	2	1	0	0	0	0	1	1	0	0	0	0	0	0	0	5	5
8	2	4	0	0	0	0	3	4	3	1	2	1	1	1	4	6	0	2	4	2	0	0	19	21
16	7	14	0	0	1	0	7	9	0	0	3	7	0	5	8	10	0	0	0	0	2	0	28	45
23	6	14	1	0	1	1	34	36	0	1	11	24	8	11	20	45	0	0	11	13	1	5	93	148
26	0	9	0	0	1	0	9	9	0	3	4	5	7	7	6	9	0	0	4	4	0	1	31	47
29	1	5	0	0	0	0	4	5	0	2	1	5	3	6	5	5	0	0	2	4	0	0	16	32
31	2	5	0	0	0	0	2	4	0	2	2	4	1	4	2	6	0	1	3	0	0	0	12	26
Sept. 6	1	1	0	0	2	0	1	2	1	2	2	1	2	5	1	1	0	0	1	1	0	0	11	13
15	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	1	3
20	3	4	0	0	0	0	1	0	0	0	0	1	3	4	4	4	0	0	4	3	0	0	15	16
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Oct. 28	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
Totals	24	58	1	0	6	1	61	72	6	11	25	48	27	48	52	84	0	3	29	29	4	6	235	361
																								596**

* Three cages on this one tree. 1 cage at 25'

** + 23 beetles sex of which was undeterminable.

M--Male
F--Female

APPENDIX

Table VII.--Emergence of Black Hills beetle from ponderosa pine, 1938 emergence. Elevation 8,000 feet.*

Collection Date	North Cages				South Cages			
	Total Dp.	Percent of Total	Total to Date	Percent of Total to Date	Total Dp.	Percent of Total	Total to Date	Percent of Total to Date
July 11	1	0.16	1	0.16	0	0	0	0
26	9	1.4	10	1.6	16	6.6	16	6.6
Aug. 2	10	1.6	20	3.2	10	4.1	26	10.7
9	42	6.8	62	10.0	18	7.4	44	18.1
16	73	11.8	135	21.8	29	11.98	73	30.0
23	243	39.3	378	61.2	68	28.1	141	58.2
26	81	13.1	459	74.3	29	11.98	170	70.2
29	49	7.9	508	82.2	34	14.1	204	84.3
31	40	6.7	548	88.7	11	4.5	215	88.8
Sept. 6	28	4.4	576	93.0	13	5.4	228	94.2
15	5	.8	581	93.9	2	.8	230	95.0
20	35	5.6	616	99.5	10	4.2	240	99.2
26	2	.3	618	99.8	0	0	0	0
Oct. 28	1	.16	619	100.0	2	.8	242	100.0
	619				242			

*Based on 12 trees, with 20 cages, for a total of 40 square feet.

APPENDIX

Table VI.--Emergence of the Black Hills beetle from ponderosa pine, 1938. South cages.

Date of Collection	Tree Number 1		2		3		4		7		8		11		12		Total		
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Both sexes
July 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	9	5	1	0	0	1	10	6	16
Aug. 2	4	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	6	4	10
8	3	8	1	1	0	1	0	1	0	0	1	0	1	1	0	0	6	12	18
16	6	9	0	2	0	1	2	1	1	1	0	3	1	0	1	1	11	18	29
23	5	12	0	0	1	0	2	6	4	3	7	16	2	7	0	2	21	46	67
26	2	1	0	0	2	2	0	2	0	10	0	0	4	5	0	0	8	20	28
29	1	5	0	0	2	2	0	1	0	4	3	3	6	6	0	0	12	21	33
31	0	0	0	0	1	1	0	0	1	1	2	2	2	0	0	0	6	4	10
Sept. 6	0	1	0	0	0	1	0	0	0	2	1	5	2	1	0	0	3	10	13
15	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	2
20	0	0	0	0	0	0	0	0	1	3	0	0	4	2	0	0	5	5	10
Oct. 28	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	2
	21	40	3	3	6	8	4	11	7	26	23	34	23	24	1	4	88	150	238*
																		238	

* + 4 beetles sex of which was undeterminable.

APPENDIX

Table VIII.--Combined total of Black Hills beetle emergence from north and south cages in 1938--ponderosa pine.*

Date of Collection	Number of Dp.	Percent of Total	Total to Date	Percent of Total to Date
July 11	1	0.12	1	0.12
26	25	2.9	26	3.0
Aug. 2	20	2.3	46	5.3
8	60	7.0	106	12.3
16	102	11.9	208	24.2
23	311	36.2	519	60.4
26	110	12.8	629	73.2
29	83	9.7	712	82.9
31	51	5.9	763	88.8
Sept. 6	41	4.6	804	93.4
15	7	0.8	811	94.2
20	45	5.2	856	99.4
26	2	0.2	858	99.6
Oct. 28	3	0.4	861	100.0
	861			

*Based on 12 trees with 20 cages for a total of 40 square feet.